SECTION 1 – SEWER DESIGN

(Last revised 3/30/05)

1.1 GENERAL

1.1.1 SPECIFICATION AND DESIGN MANUAL:

A. All projects within the jurisdiction of the City of Fairfax shall be designed and constructed in accordance with the City's *Public Facilities Manual*, latest revision.

B. Sanitary sewer gravity mains, force mains, and lift stations shall conform to the design and construction requirements of the *Manual of Practice for Sewerage Systems and Treatment Works*, Article 1, *Collection and Conveyance Sewers*, 9 VAC 25-790-310 through 440 as published by the Commonwealth of Virginia, Virginia Department of Health (VDH), latest revision, which documents are herein incorporated by reference and made part of this document.

1.1.2 ENGINEERING REPORT REQUIREMENTS:

When required by the Utilities Engineer and prior to proceeding with design, the developer shall be required to provide a brief Engineering Report satisfactory to the Utilities Engineer, which shall define:

A. The service area limits, design flows, and capacities of the utility extension under question.

B. The development area limits and percentage of line capacity utilized by the developer.

1.1.3 PERMITS:

A. **Plan Approvals, Sewer Permits:** Prior to commencing construction, all plan approvals and/or sewer permits shall be obtained. A preconstruction conference with the City Inspector must also be held prior to commencing any construction.

B. **Right-of-Way Permits:** A right-of-way permit will be required from any Contractor or Developer wishing to excavate or place utilities in VDOT right-of-ways.

C. **Pavement Cuts:** Pavement cuts in streets shall be repaired in accordance with the specific requirements of public agency on whose street or roadway the utility is being placed, as well as any other applicable requirements dictated in the approved right-of-way permit. Open cut or bored crossings shall otherwise adhere, as applicable, to specification Section 02275 – *Trenching, Backfilling & Compaction of Utilities* as well as **Standard Details 401.07 and 401.08**, as applicable.

D. Developer must obtain all other Federal, State, and Local permits, as applicable (Air Quality, Wetland, DEQ, Chesapeake Bay Preservation, Zoning, VPDES, etc.)

1.1.4 PLAN REVIEW AND OBSERVATION FEES

All plan review and observation fees must be paid prior to acceptance of project. Refer to the current City fee schedule for applicable fees.

1.2 WATER SYSTEM DESIGN STANDARDS

The purpose of this module is to establish standard design procedures and criteria for water system design in the City of Fairfax, and Fairfax Water.

A. **General:** Distribution systems shall meet the minimum requirements of the Virginia Department of Health *Waterworks Regulations, latest revision*s and all applicable Fairfax Water requirements.

1) **Water Supply System:** The subdivider shall connect the subdivision or development with the water system at his expense, and shall construct it in such a manner as to serve adequately for both domestic use and for fire protection.
2) No new permanent structure or pond shall be constructed over water mains or located within water or sewer easements.

1.2.1 FIRE DEMAND

A. **Computation:** Demand forecasting projects the future water use based on historic use factors, socioeconomic trends, climatic factors and other parameters. Distribution system design must also account for peak periods of daily use. Peak factors are a function of land use, present population, and population growth rate. Older established areas tend to have peak factors two to three times lower than those of rapidly expanding areas.

Although the overall volume of water used for fighting fires is quite low relative to most other uses, the rate at which it must be supplied places a heavy, short-term drain on the system. Various types of forecasting models may be used; the least complex of which is a single-coefficient method used herein. Here, the projected demand is based on a factor relating to type of construction and square footage of the structure.

Fire Demand: The minimum amount of fire flow for any development shall be to the satisfaction of the Fire Marshal. For design purposes; however, the ISO *Guide for Determination of Needed Fire Flow* and the latest revision of the *Virginia Statewide Fire Prevention Code* shall be used to determine fire demand. The estimated fire flow can be established in the following equation from the ISO *Guide for Determination of Needed Fire Flow* used by ISO (Insurance Services Office).

The following minimum requirements shall be applied:

Exposure Distance (feet)[X]	**Required Flow (gpm)**
Single Family Homes	
Less than 10	2000
Greater than 10 to 30	1500
Greater than 30	1000
[X]*Separation between structures*	
Residential and Commercial Townhouses	3000
Other Structures	
The maximum flow (C_i) shall not exceed	7500
The minimum flow (C_i) shall not be less than	1500

To estimate the amount of water required to fight a fire in an individual, nonsprinklered building, ISO uses the formula:

$$NFF_i = (C_i)(O_i)(1+(X+P)_i)$$

Where,

NFI_i = the needed fire flow in gallons per minute (gpm)
C_i = a factor related to the type of construction
O_i = a factor related to the type of occupancy
X = a factor related to the exposure buildings (see ISO **Table 330A**, *Factor for Exposure*)
P = a factor related to the communication between buildings (see ISO **Table 330B**, *Factor for Communications*)

Fire Flow Formula:

$$C_i = 18F(A)^{1/2}$$

Where,

C_i = required minimum fire flow (gpm)
F = coefficient related to class of construction
A = effective area (total gross floor area in square feet, including all stories, but excluding basements)

Note: ISO rounds the calculated value of C_i to the nearest 250 gpm

Values of F (Coef related to the class of construction)		
Construction Class	**Description**	**Factor** (*F*)
1	Wood Frame	1.5
2	Joint-Masonry	1.0
3	Non-combustible	0.8
4	Masonry, Non-combustible	0.8
5	Modified Fire-resistive	0.6
6	Fire-resistive	0.6

Coefficients should not be greater than 1.5 nor less than 0.6 and may be determined by interpolation between consecutive types of construction as listed.

Occupancy Factor	
Occupancy Combustibility Class	**Occupancy Factor** *(O_i)*
C1 (Non-Combustible)	0.75
C-2 (Limited Combustible)	0.85
C-3 (Combustible)	1.00
C-4 (Free-Burning)	1.15
C-5 (Rapid-Burning)	1.25

A. **Fire Hydrants:** Whenever possible, fire hydrants shall be located on distribution mains having a diameter of 8 inches or more. Not more than one fire hydrant shall be located on a 6-inch dead end main and the fire hydrant shall be located not more than 300 feet from a looped main. Multiple (more than 1) hydrants shall not be installed on less than an 8-inch main.

1) **Fire Hydrant Location (Maximum Distances from Structures):**

a. In water systems and extension serving one- or two-family residential areas, fire hydrants shall be installed at such locations that there will be at least 1 fire hydrant within 300 feet of the nearest wall of any building (existing or proposed in ultimate development) served by said system or extension. Also, fire hydrants are required to be located such that the remote corner of any lot is within 500 feet. Placement of hydrants will be coordinated with Fairfax Water.

b. Hydrants along streets or roads on which such one- or two-family residences front shall be spaced not more than 500 feet apart.

c. In commercial, industrial, apartment, and townhouse areas, fire hydrants shall be provided as required to meet the fire protection standards of the American Insurance Association. In no case shall more than 300 feet of fire hose be required to reach any point at the base of any exterior building wall from the nearest fire hydrant or from each of the hydrants required to supply the stipulated fire flow.

d. Fire hydrants required by the Utilities Department for flushing or other purposes may not be acceptable to the Fire Marshal for firefighting needs and additional hydrants may be required (i.e., hydrants used for flushing in lieu of blow-off assemblies at cul-de-sacs or dead end roads as requested by Utilities Department).

e. Fire hydrants located on the opposite side of a City designated Arterial or Collector streets shall not be considered to meet the proximity requirements.

f. Additional requirements may be imposed by the Fire Marshal where deemed necessary.

g. **Minimum distances from a structure:** No new hydrant shall be located closer than 40 feet from a structure.

2) All hydrants are to be located in a street right-of-way or Fairfax County Water Authority easement.

3) **Hydrant in Relation to Street:** See **Standard Details 514.01, 514.02**, and **514.03** (fire hydrant dead end street application).

4) **Services on Fire Hydrant Branches:** Services on fire hydrant branches are not permitted.

5) **Acceptance of New Hydrants:** Prior to the City accepting a new hydrant on to their system, the project design engineer, or his representative, shall provide to the City a flow test from the hose nozzle of each hydrant on the system using a calibrated oil filled pito gauge. A Professional Engineer shall certify the written report. The report shall consist of the date of test, the design flow pressure (or minimum flow limits required for the hydrant) as well as the actual calculated flow. This data shall be correlated back to the design flows to verify whether the system, as constructed, agrees substantially with the design flows and that there are no valves closed on the new system. Fire hydrants shall be painted and identification rings attached in accordance with **Standard Details 514.01, 514.02,** and **514.03**.

B. **Fire Lane Requirements:**

The Fire Marshal shall designate fire lanes on private property where necessary to ensure that firefighting and rescue apparatus has the required access to fire

department connections, buildings, and structures. Fire lanes shall have a minimum clear width of 18 feet. Fire lanes serving structures greater than 30 feet in height or serving schools shall have a minimum clear width of 22 feet. Pavement sections shall be designed to support vehicles weighing up to 75,000 lbs. using asphalt or other approved surfaces. "Grass-Crete" shall not be used as a paving surface for fire department vehicle access, but may be accepted in short sections for egress in lieu of a compliant turnaround at the sole discretion of the Fire Marshal. "Dead End" fire lanes over 150 feet in length shall be provided with an approved turnaround. Approved turnarounds include a 90-foot diameter cul-de-sac, a 120-foot hammerhead or a 60-foot "T" set 60 feet from the end of the fire lane. All curved sections of fire lanes shall have a minimum radius of 45 feet.

Fire lanes shall not exceed 10% slope in any direction. Where gates are to be installed across a fire lane, the following conditions must be observed:

1) The gates must be maintained in an operable condition or be fixed in the open position.

2) A means of manually opening the gate in the event of power failure must be provided.

3) A key operated switch and automatic operation compatible with the City traffic signal preemption system shall be provided.

Fire Lane Signs and Markings: The property owner or designee shall supply and install signs and other required markings to delineate fire lanes as directed by the fire official, the cost of which will be borne by the property owner or designee.

Sign Specifications: Fire lane signs shall conform to the following specifications. Signs shall be of metal construction, 12 inches wide x 18 inches high with red letters on a reflective white background. There shall be a 3/8-inch wide trim strip around the entire outer edge of the sign. Signs shall be mounted with the top of the signs 7 feet above grade. Where pedestrian traffic may pass by or under sign, raise sign to provide a clearance beneath sign of 84 inches.

Lettering sizes shall be as follows:

"NO PARKING" – 2 inches,
"OR" – 1 inch
"STANDING" – 2 inches
"FIRE LANE" – 2 ½ inches
Arrows shall be 1-inch solid.
Spacing between words to be uniform

Type "A"
(Arrow to the right)

Type "B"
(Arrow to the left)

Type "C"
(Arrow in both directions)

Type "D" = 2 signs back-to-back perpendicular to street with NO ARROWS.

1) Other type signs or marking as approved by the Fire official.
2) Signs shall be posted at intervals and at a height above the finished grade as directed by the Fire official.
3) Curbing shall be painted yellow within the limits of the fire lane.
4) Contact the Fire Marshal's office at 703.385.7830 when signs are in place for final approval.

1.3 GRAVITY SANITARY SEWER COLLECTION SYSTEM DESIGN STANDARDS

The purpose of this section is to establish standard design procedures and criteria for sewer system design in the City of Fairfax.

1.3.1 GENERAL

A. **General:** Gravity Collection systems shall meet the minimum requirements of Virginia Department of Health *Sewerage Regulations*, latest revision.

B. **Sewer Collection System:** The subdivider shall be required to connect his subdivision with the municipal sewage system at his expense according to Section 86 – *Subdivisions* of the City of Fairfax code.

C. **System Design:** The system is to be designed for the estimated ultimate tributary population including consideration given to the maximum anticipated capacity of institutions and industrial parks, etc. The capability of the downstream sewers to accept the future flow from tributary collection systems shall be evaluated by the design engineer. Wastewater flows shall be determined in accordance with *the Sewage Collection and Treatment Regulations, Part I,* 9 VAC 25-790*, Manual of Practice for Sewerage Systems and Treatment Works*, Article 1, *Collection and Conveyance Sewers*, 9 VAC 25-790-310 through 440 as published by the Commonwealth of Virginia, Virginia Department of Health (VDH).

1.3.2 DEFINITIONS

A. **Definitions:** For the purposes of this specification, the following definitions refer to sanitary sewer collection systems that come under the authority of the City of Fairfax, Virginia as specified within this section and other sections of this manual.

1) **Main, Sub-Main or Trunk Sanitary Sewer:** Exterior gravity sanitary sewer systems receiving flow from one or more lateral or mains.

2) **Sewer Service (Lateral):** Exterior domestic sewer piping serving a private residence, business, commercial facility or industrial user.

3) **Interceptor:** Sewer that receives flow from a number of gravity mains, sub-mains or trunk sewers, usually placed along a stream or river.

B. The following are industry abbreviations for various pipe materials:

1) **DIP:** Ductile Iron Pipe

2) **PVC:** Polyvinyl Chloride Plastic

3) **RCP:** Reinforced Concrete Pipe

1.3.3 COLLECTION SYSTEM DESIGN

A. **Tributary Population:**

1) Sewer systems which provide for a complete watershed shall be designed and sized taking the following into consideration:

a. The estimated tributary population or a period of 50 years hence, or

b. The entire watershed shall be assumed to be completely built out according to present or predicted zoning ordinances, whichever requires the greater capacity.

2) Sewer systems which provide for only a part of a complete watershed shall be sized to provide for the entire watershed. Otherwise, provisions shall be made for future increased capacity. Proper modification to allow for the characteristics (i.e. domestic, commercial, and industrial wastes and groundwater infiltration) of the area under consideration shall be made.

3) Trunk and sub-trunk sewers shall be designed on a basis of a population density of no less than 10 persons/acre. Design provisions in excess of this minimum shall be made where the engineer deems it necessary. Supporting data shall be included in the design analysis.

B. **Capacities:**

1) In determining the required capacities of sanitary sewers, the following factors shall be considered:

   a. Maximum hourly quantity of domestic sewage.

   b. Additional maximum sewerage or water from industrial plants and commercial areas.

   c. Ground water infiltration.

2) New sewer systems shall be designed on the basis of an average per capita flow of sewage from the equivalent population served of not less than 100 gallons per day. On this basis, lateral and sub-main sewers shall be designed with capacities, when running full, in accordance the peak flows.

   The minimum peak design for interceptor sewers shall be 200% of the average daily flow. These factors include infiltration but exclude inflow. If inflow is anticipated or known to exist in upstream sewers, the Utilities Engineer may require that the design flow be increased accordingly and the justification/computation/source referenced in the design calculations and provided to the Utilities Engineer for review.

3) The 100 gallons per capita per day figure is assumed to cover normal infiltration, but an additional allowance shall be made where conditions are especially unfavorable. This figure is likewise considered sufficient to cover the flow from cellar floor drains, but is not sufficient to provide an allowance for flow from foundation drains, roof leaders, or unpolluted cooing water, which are prohibited by law from discharging into sanitary sewer systems.

4) Unless evidence is presented to prove a different flow from industry at ultimate development, the minimum allowance for industrial flow shall be determine by providing an equivalent population of 40 persons per acre or one equivalent population per employee, whichever is the greater, in the industrial areas. “Area” shall include entire areas zoned for industry, except public road, street and highway rights-of-way, flood plains on which construction is prohibited, and “green zones” separating industrial from residential areas, on which construction is prohibited.

5) The minimum allowance for flows from commercial areas shall be determined by providing an equivalent population of 30 persons per acre or one-half the equivalent population per employee, whichever is greater, in the commercial areas. Areas shall include entire areas zoned for commercial development, including off-street parking areas and landscaped areas, but excluding the rights-of-way of public roads, streets and highways, flood plains of streams on which construction is prohibited and “green zones” 100 feet or more wide separating commercial from residential areas, on which construction is prohibited.

6) In cases where the above criteria are not applicable, an alternate design procedure may be submitted to the Department for approval. A description of the procedure used and justification for the modifications for sewer design

proposed shall be included with the design analysis and plans submitted for approval.

C. **Minimum Size/Sizing:** No public gravity sewer conveying wastewater shall be less than 8 inches in diameter.

D. **Sewer Connections:** Connections to sewer lines 6-inches in diameter and larger shall only be made at manholes.

1.3.4 STRUCTURAL DESIGN

A. **General:** The structural design of sewers shall conform with the methods given in the latest revision of ASCE Manual No. 37 for the Design and Construction of Sanitary and Storm Sewers, latest revisions, except where modified hereinafter.

B. **Working Strength:** The working strength for rigid pipes shall be the minimum ultimate 3-edge bearing strength divided by a safety factor of 1.5.

C. **Allowable Load:** The allowable load shall be the working strength times the load factor shown below:

1) In trench condition:

Type Bedding	Load Factor
Class A (Concrete Cradle or Arch)	2.5
Class B	1.9
Class C	1.5

2) In embankment condition:

Same as listed above for Trench Condition: (Embankment Condition = pipe installed with the pipe projecting above the original ground level and but backfilled to a minimum of 2 feet above the proposed top of the pipe).

D. **Dead Load:**

1) In trench condition: Unless more specific data is available, the dead load shall be computed suing the following values:

Backfill Weight, w = 130 pcf
Ku = Ku' = 0.130 (ordinary clay curve)

2) In embankment condition: Formula and curves are given in VDOT Standards.

Backfill Weight, w = 130 pcf

E. **Live Load:** The load on the pipe due to surface wheel loads shall be determined from the graph of Figure III. The minimum wheel load equivalent to an H-20 loading (16,000 lb. wheel load) shall be applied to all sewers under existing and/or future streets, roads, drives, and highways. An allowance of 50% of the

design wheel load shall be added for impact. A minimum wheel load of 10,000 pounds per wheel shall be applied to all other sewers.

F. **Bearing Strength:** Severe loads under unusual conditions may be accommodated by using ductile iron pipe which is heavier than the minimum allowed. In such a case, the ultimate minimum 3-edge bearing strength shall be determined by the following formula:

$$W = \frac{tR}{0.0795(d+t)}$$

Where,

***t* =**	average barrel thickness of pipe (inches) minus 0.20 inches for corrosion and factory tolerance
***R* =**	Modulus of Rupture (31,000 psi for pit cast iron) (40,000 psi for centrifugally cast iron)
***d* =**	average internal diameter of pipe (inches)
W =	value of equivalent 3-edge bearing strength

G. **Bedding of Pipe:** All sewer pipe shall be bedded by one of the methods shown in **Standard Details 511.01 and 511.02**. The bedding used in design shall be compatible to that obtainable in the field.

1.3.5 ACCEPTABLE PIPE MATERIAL

A. Refer to of Section 02530 – *Sanitary Sewer, Part 2 - PRODUCTS* for detailed specifications for pipe and fittings. Use pipe, fittings, and joining methods according to the application indicated. Also refer to Section 02275 – *Trenching, Backfilling, and Compaction of Utilities*.

B. Pipe Materials for Public Sewers:

Allowable Materials for Sewer Pipe up to 12 inches in diameter	
Gravity Mains	DIP
	PVC AWWA C900 (DR 25)
Force Mains	Cement Lined DIP
Services	As required by the City of Fairfax Code Enforcement Division

Allowable Materials for Sewer Pipe 14 inches or larger in diameter	
Gravity Mains	PVC AWWA C905
	DIP

1) RCP, PE, or VCP is not permitted.

C. In the system design, the engineer may consider control of hydrogen sulfide generation through system design and/or use of corrosion resistant high alumina (calcium aluminate) pipe linings.

1.3.6 LOCATION

A. **Location:** All sewer mains shall be installed within the street right-of-way or within a dedicated sewer or utility easement. Preferably, the sewer shall be located equidistant from property lines or curb lines wherever possible.

1) The horizontal distance between sewers and existing or projected water mains shall be not less than 10 feet except where the water mains are located at a higher elevation (1.5 feet above top of sewer minimum) than the top of the sewer, in which case, a minimum horizontal distance of 6 feet will be permissible.

2) Deflection angles for all horizontal turns shall be shown and elevations shall be tied to mean sea level reference datum, including benchmarks. Plans must show manhole number, top elevations, station, slope, and depth along with invert elevations.

3) Where tributary flow is expected from an upstream natural drainage basin, designers shall provide extensions of sewer mains to the farthest property line of the tract.

4) **Crossing Other Utilities**: When other underground utilities are encountered, (i.e. telephone lines, gas lines, cable TV, etc.) 12-inches of separation should be maintained.

5) **Sewer/Well Conflict:** If a sewer main is installed within 100 feet of an existing well, watertight joints meeting Virginia Department of Health requirements shall be employed in the sewer line for all portions of the sewer line within a 100-foot radius of the well. In the event a sewer line is installed within 25 feet of a well, the well shall be capped and the property shall be required to connect to Fairfax Water's water system if available or either the existing well abandoned a new well drilled meeting the setback requirements.

B. **Sewers in Relation to Streams and Other Bodies:**

Sewers locate in relation to streams, lakes and reservoirs shall meet the following requirements:

1) **Alignment:** Sewers crossing streams shall be designed to cross the stream as nearly perpendicular to the stream flow as possible.

2) The tops of all sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the streambed to protect the sewer line. In general, 1 foot of suitable cover shall be provided where the stream is located in rock and 3 feet of suitable cover in other material. Less cover will be considered if the proposed sewer crossing is encased in concrete and will not interfere with future improvements to stream channel. Reasons for

requesting less cover shall be given in the application. In paved channels, the top of the sewer lines should be placed below the bottom of the channel pavement. All sewers below the 25-year WSEL shall be encased.

3) Sewers and their appurtenances located along streams shall be protected against the 100-year flood. Sewers located along streams shall be located outside of the streambed wherever possible and sufficiently removed therefrom to provide for future possible channel widening. Reasons for requesting sewer lines to be located within streambeds shall be given in the application.

   The sewer interceptors, manholes, or other structures shall be located so they do not interfere with free discharge of flood flows of the stream. Portions of manholes above grade subject to hydrodynamic forces of flooding shall be designed to resist the flood forces with a safety factor of 2.5 considerations shall be given for impact from debris.

   Sewers paralleling creeks shall be below the stream elevation, such that lateral connections will be below streambed whenever possible. In certain circumstances where rock is present, sections of the main may be raised to allow lateral connections above the streambed provided the ability to serve the upstream property is not compromised and the pipe crossing is designed sufficiently restrained to prevent line breakage by the dynamic effects of the stream flow.

4) Sewers crossing streams shall be Class 52 rated ductile iron, encased in concrete, from manhole to manhole. Concrete encasement shall extend 10 feet beyond the bank on both sides of the stream. The pipe and joints shall be air-tested in place. The joints shall exhibit “0” infiltration and shall be designed, constructed, and protected against anticipated hydraulic and physical, longitudinal, vertical, and horizontal loads and erosion and impact.

   Material used to backfill the trench shall be stone, coarse aggregate, washed gravel or other materials that will not readily erode, cause siltation, damage pipe during placement, or corrode the pipe.

C. **Public Easements:**

The minimum width of easements (except when adjacent and parallel to right-of-way) shall be 10 feet. Consideration shall be given for deeper cuts (generally greater than 12’) by including an additional temporary construction easement (usually 10’ - 50’). The Director of Public Works may require that the width of the **permanent easement** increase with the depth of sewer for maintenance purposes.

Except at stream crossings and as may be limited by wetland permit requirements, easements shall be fully accessible by rubber-tired vehicles. The City may require that small streams be piped, provided crossings are consistent with USCOE requirements.

1.3.7 SERVICE CONNECTIONS

A. Services connected to gravity sewers shall be connected using in line wyes and tees only. Service saddles may be used on pre-existing mains. All wyes and tees shall be embedded in stone. See **Standard Details 534.01 and 534.02** for service tap detail. Connections to sewer lines 6 inches or larger shall be made at manholes.

B. **Connections to Trunk Line Sewers:** Trunk line sewers may not be tapped, but where available and with the approval of the Department of Public Works, building sewer may enter a trunk line manhole and a satisfactory bench and invert built at the expense of the developer. If no manhole is available, permission to construct a new manhole must be secured from the Director of Public Works and it must be built at the developer's expense and under the direction of the Director of Public Works.

C. **Tap Size:** No 8-inch sewer shall be tapped for a building sewer larger than 4 inches unless approved by the Director of Public Works.

D. A cleanout will be installed on each house service. Unless topography prohibits, place services at low side of lot.

E. The cleanout shall be located outside the right of way or the easement line on the City side of the property line as shown on **Standard Detail 534.01**.

F. See **Standard Details 534.01 and 534.02** for service lateral slopes.

1.3.8 DEPTH/MINIMUM COVER

The depth of sewer mains should be such that they are deep enough to serve all upstream properties within the drainage basin.

A. Sewer shall generally be installed with a minimum cover of 6 feet below the finished street surface or ground. In isolated instances where only a few houses are served and where the required 6 feet or greater depth would excessively increase construction costs, shallower depths at the upper end may be permitted. Sewers at shall depths shall be protected against possible damage by superimposed loads or the effects of traffic.

B. Where approved by the Department, sewers with less than 3 feet of cover shall be ductile iron or encased in concrete. Sewers with 18 feet or more of cover shall be DIP.

1.3.9 BUOYANCY

Buoyancy of sewers shall be considered and flotation of the pipe shall be prevented with appropriate construction where shallow cover and high groundwater or flooding conditions are anticipated. For design purposes, assume water to top of pipe and pipe is empty.

1.3.10 HYDRAULIC DESIGN CRITERIA

The hydraulic design and determination of sewer sizes shall be based on the following conditions:

A. Sewers shall have a uniform slope and straight alignment between manholes. Horizontally curved sewers shall not be used unless specifically approved by the Public Works Department.

B. At all junctions where a smaller diameter sewer discharges into a larger one and at all locations where the sewer increases in size, the invert of the larger sewer shall be lowered so that the energy gradients of the sewers at the junction are at the same level. Generally, this condition will be met by placing the crowns of both sewers at the same elevations.

C. Sewers shall be designed to be free flowing with hydraulic grade below the crown and with hydraulic slopes sufficient to provide an average velocity when running full of not less than 2.25 feet per second (fps). Computations of velocity of flow shall be based on the following values of "n," as used in the Kutter or Manning formula for velocity of flow. "n" shall be no less than the following:

Sewer Size (inches)	"n"
8 to 27(laid in lengths of 20 feet)	0.013
30 and greater (laid in lengths of 4 feet or more with tongue and groove joints made carefully smooth)	0.012

D. For sewage flow depth less than ¼ full, allowances shall be made for increased value of "n" and in no case shall velocities of less than 1.3 fps be permitted. The improved velocities shall be accomplished by steeper grades and not by decreasing pipe diameter.

1) **Considerations for Low Flows:**

On upper reaches of small services and mains, due to water saving fixtures now employed, the designer should give consideration to increasing the slope of gravity services above the minimum allowed in order to flush solids.

Special attention must also be given to the fact that initial flows may be substantially lower than design flows and the velocities well below the minimum. The designer or the Utilities Engineer may direct usage of greater slope or require developer to provide periodic flushing until sufficient flow has been developed to provide a self-scouring velocity.

E. The maximum permissible velocity at average flow (before applying peak flow factor) shall be 10 fps. Where velocities must exceed 10 fps, the sewer shall be

constructed of ductile iron pipe. Suitable drop manholes shall be provided to break the steep slopes to limit the velocities in the connection sewer pipes between manholes. Where drop manholes are impracticable for reduction of velocity, the sewer shall be of ductile iron or other abrasion resistant material.

F. In general, the following minimum slopes in feet per hundred feet to be provided for pipes flowing full depth to one-fourth of full depth shall be:

Table 3.1

Sewer Size (inches)	Minimum Slope (%) for Pipe Lengths up to 20 feet
8	0.47
10	0.34
12	0.26
15	0.18
18	0.14
21	0.113
24	0.088
30	0.062
36	0.048
42	0.040

Terminal sections of sewers discharging into lift stations, sewage treatment plants, plant effluent into streams, etc. will require a minimum slope of double that indicated in above table.

G. Miscellaneous head losses at manholes and junction boxes shall be allowed for as follows:

1) At manholes on straight runs, allow head loss of 0.05 feet.

2) **Minimum Drop Across Invert:** The minimum drop between manhole invert in and invert out is 0.05 feet on straight junctions. Other drops (H), where there is no change in pipe size, can be computed by applying the following headloss (*K*) coefficients to the velocity head:

$$H = K\left(\frac{V^2}{2g}\right), \text{ where}$$

H = Vertical drop across invert of manhole (ft)
K = Headloss coefficient (from table below)
V = Average velocity in influent pipe (ft/sec)
g = Acceleration of gravity (32 ft/sec$^{2)}$

3) **Turns Made Inside Manholes:**

Condition	K
For bends at junctions of 25 degrees	0.30
For bends at junctions of 45 degrees	0.40
For bends at junctions of 90 degrees:	
Radius < 2 pipe diameters	0.50
Radius > 2 pipe diameters	0.25
For junctions of 3 pipes	0.80
For junction of 4 or more pipes	1.00

(Reference: King's handbook of Hydraulics)

In no case shall total allowance be less than 0.05 feet.

4) At transitions and intersection of sewers larger than 24 inches in diameter, each case shall be investigated separately and the hydraulic analysis shall be submitted to the Department of Utilities for approval.

5) In general, the pipe diameter of sub-trunk sewers shall be continually increasing with increase in tributary flow. Where steep ground slopes make possible the use of a reduced pipe size and a substantial economy of construction cost can be derived, the pipe size may be reduced; but, due hydraulic allowances shall be made for head loss at entry, increased velocity, and the effect of velocity retardation at the lower end where the flow will be on a flatter slope. In no case shall pipe diameter sizes be thus reduced below 12-inches.

6) **Steep Slope – Pipe Anchorage:** Sewers constructed on 20% or greater slope shall be anchored both to prevent the sewer pipe from creeping downhill and/or to prevent water from flowing along the pipe and causing the trench to wash out. The lines shall be securely anchored with concrete anchors. Suggested minimum spacing of anchors shall be as follows:

Table 3.2

Grade Range (% slope)		Anchor Spacing (center to center in feet)
From	To	
20	<35	36
35	<50	24
50	or greater	16

H. **Changes in Pipe Size or Material:**

1) **Pipe Size Changes:** Gravity sewer sizes shall remain constant between manholes.

2) **Undersized or Substandard Downstream Sewers:** Contact the Utilities Engineer for design considerations.

3) **Pipe Material Changes:** To avoid couplings of dissimilar material, pipe material must remain consistent between manholes and may not be changed. In some cases, it may be necessary to have dissimilar materials join at drop

manholes. In this case, the joint shall occur where the main approaches a drop manhole.

1.3.11 INVERTED SIPHONS

Inverted siphons must be pre-approved by the Department and will be considered only after all alternate designs have been determined as impractical. An inverted siphon of minimum size (6-inch) should not serve a population of less than 3000. Inverted siphons shall have not less than 2 barrels with a minimum pipe size of 6 inches and shall be provided with necessary appurtenances for convenient flushing and maintenance; the manhole shall have adequate clearance for rodding; and in general, sufficient head shall be provided and pipe sizes selected to secure velocities of at least 3 fps for average flows. The inlet and outlet details shall be so arranged that the normal flow is diverted to 1 barrel and in such a manner that either barrel may be cut out of service for cleaning.

1.3.12 TESTING AND ALLOWABLE LEAKAGE

See specification Section 02530 – *Sanitary Sewer* for testing requirements.

1.3.13 DESIGN – MANHOLES

A. **Location:**

1) **Manholes Shall Be Installed**: On all mains 8 inches and larger, manholes shall be installed at the terminal end of the line, at all changes in grade, changes in pipe material, at changes in main size or alignment, at all intersections with other sewers, and at distances not greater than 400 feet for all sewers 15 inches or less in diameter. For sewers 18 inches to 30 inches in diameter, at not more than 500 feet apart.

2) Manholes shall be designed in detail incorporating the features shown on **Standard Details 532.01, 532.02, 532.03, and 532.04**.

B. **Diameter:**

1) **Minimum Diameter:** The minimum diameter of manholes shall be 4 feet. The minimum diameter of inside drop manholes shall be 4 feet.

2) **Diameter Based on Pipe Size:** Manholes shall be 4-foot minimum diameter for lines up through 18 inches. Manholes for sewers larger than 18 inches up through 48 inches shall have an inside diameter of not less than 5 feet.

3) **Diameter Based on Depth:** Manholes 0 to 20’-0” shall be 4-foot in diameter minimum. Manholes greater than 20 feet deep shall be 5 feet in diameter. All manholes shall have extended bases. Manholes greater than 20 feet in depth may be transitioned, at the 20-foot depth, from a 5-foot diameter to 4-foot diameter manhole except after a minimum of 5’ of riser (height) from invert of manhole.

4) **Cones:** Eccentric cones are preferred in all cases.

5) **Minimum Drop Across Invert:** The flow channel through the manholes shall be made to conform in shape and slope of the sewer. However, the minimum drop between manhole invert in and invert out is 0.05 feet on straight junctions. See paragraph *1.3.10, Minimum Drop Across Invert*.

C. **Drop Type:**

1) A drop shall be provided for a sewer entering a manhole at an elevation greater than 18 inches or more above the invert of the manhole unless sewer pipe crowns match elevations or as may otherwise be required to conform to the use of standards fittings in the drop pipe construction. Where the difference is less than 18 inches, the base of the manhole shall be so filleted as to prevent solid deposition.

2) **Inside Drops:** Inside drops will be permitted on a case-by-case basis. See **Standard Detail 532.06.**

3) **Outside Drops:** Not permitted.

D. **Doghouse Manhole:**

Manholes placed over existing mains shall be constructed in accordance with **Standard Detail 532.04**.

E. **Water-Tightness:**

1) Manholes shall be pre-cast concrete.

2) **Pipe Connections to Manholes:** Inlet and outlet pipes shall be joined by core drilling to the manhole with gasketed flexible watertight connections (rubber boots). See **Standard Details 532.01 and 532.02.**

3) Manholes shall extend above the maximum known stage of floodwaters 2 feet unless improvements, such as street grades, will not so permit. In such cases, watertight manhole covers shall be used wherever the manhole tops may be flooded by street runoff or high water.

4) **Ventilation:** Ventilation of gravity sewers shall be provided where continuous watertight sections greater than 1000 feet in length are incurred. See **Standard Detail 536.01**.

F. **Buoyancy:** Buoyancy shall be considered and flotation of the manholes shall be prevented with appropriate construction where high groundwater or flooded conditions are anticipated. For design purposes, assume water to top of manhole and that the manhole is empty.

G. **Inspection and Testing:** See technical specification Section 02530 – *Sanitary Sewer* for testing requirements.

H. **Coating:** All manholes shall have bituminous coating on the outside walls.

I. **Corrosion Protection for Manholes:**

1) Where corrosion conditions due to septicity or other causes are anticipated, corrosion protection shall be provided on the interior of the manholes. Consequently, drops in interceptor lines or drops into interceptor lines shall be avoided. Drop manholes, if required, shall be provided upstream of interceptor line connection.

2) Where high flow velocities are anticipated, the manholes shall be protected against internal erosion by providing erosion resistant coatings, sacrificial concrete, or other approved means. Manholes shall also be protected against displacement from impact.

1.3.14 PROTECTION OF POTABLE WATER SUPPLIES AND STORM SEWERS

A. **General:** See specification Section 02530 – *Sanitary Sewer, Part 1- General, paragraph 1.10, Project Conditions* for separation requirements between water mains and sewer mains/manholes and water mains and drainage structures/streams.

1.3.15 Pump Stations

A. **General:**

Pump stations and force mains will be allowed only with the permission of the Utilities Engineer.

Pump stations shall be City of Fairfax standard. Pumps shall be self-priming pumps with electro-mechanical controls. Pumps shall be designed for continuous duty pumping raw, unscreened wastewater.

Self-Priming Pumps: Self-priming pumps shall have alternating (transducer or float) system switches. Pumps and related controls shall be enclosed in a building. Though not preferred, with the Utilities Engineers prior approval, a rollback "Quonset" style fiberglass enclosure may be permitted. Pumps shall be capable of handling a 3-inch solid and any trash or stringy material that can pass through a 4-inch hose unless mechanical means of solids reduction is installed at the pump. Pumps shall be made non-clog by passing solids, trash, and stringy material through a non-clog impeller. Impellers shall have blades that are generally forward rounded or otherwise configured to avoid catching solids, trash, and stringy material.

Lift stations shall include the following as a minimum:

1) **Inspection and Testing:** See technical Section 02530 – *Sanitary Sewer* for manhole testing requirements.
2) Service head, meter base, service connection, disconnect, and area light with switch.
3) Audible and visual high water alarm and alarm silence.

4) Auto-dialer (minimum 8 numbers, 4 channels). The automatic telephone dialer shall be a solid-state component capable of dialing up to 8 phone numbers, each up to 24 digits in length. The dialer shall have solid-state voice message recording and playback, all implemented with permanent nonvolatile solid-state circuitry with no mechanical tape mechanism.
5) Automatic air release valves, as applicable.
6) For self-priming pumps, provide floats or transducer type control system with hand-off-automatic (H-O-A) switches and an automatic alternator. For submersible pumps, provide mercury float switches for level control.
7) High water alarm circuitry.
8) 3-phase voltage monitor, if applicable. Indication of 3-phase power fails. All motors shall have a low voltage protection device which, on the reduction or failure of voltage, will cause and maintain the interruption of power to that motor. The low voltage protection device should protect each phase of 3-phase motors.
9) Suction and/or discharge gauges, as applicable.
10) Elapsed time indicators.
11) High pump temperature protection.
12) Pump run lights.
13) Motor overload resetter.
14) Surge suppressor.
15) Duplex service receptacles on GFCI.
16) Surge relief valve and return piping to wet well.
17) Start-up assistance and certification, including operational/witness/drawdown test. Certified pump curves shall be provided as part of the project closeout documents.
18) Dual power supply auto switchover, etc.
19) For self-priming pump stations, provide heaters and fluorescent lighting.
20) The lift station is to include back-up alarm system that operates off a 12-volt battery connection in the event of power failure. The battery system is to include a trickle charger to ensure battery integrity.
21) When required by the Utilities Engineer, based on reliability (see 9 VAC 25-790-390), provide auxiliary natural gas or diesel fired automatically activated stand-by power generator source with automatic reset, placed on site. Pump manufacturer to provide power demand/ratings to contractor before ordering pump and the power demand appropriately marked on the pump shop drawings. Generator shall have the capacity sufficient to sequentially start and run all pumps in the pump station. The contractor shall provide a complete engine driven generator set. The generator set shall consist of four-cycle, radiator-cooled, engine direct connected to an alternating current generator, a unit-mounted control panel, all mounted on a common sub-base. The control panel shall be complete with engine controls and instruments, safety controls and panel lights including the following:

    a. The generation unit shall be capable of powering the pump motors starting current, electrical systems, instrumentation /controls and alarm systems, and other auxiliary equipment as may be necessary to provide for the safe and effective operation of the pump station. The generation unit shall have the appropriate power rating to start and continuously operate under all connected loads. The starting system shall be

appropriately alarmed and instrumented to indicate loss of readiness (e.g. loss of charge on batteries, loss of pressuring in air accumulators, etc.).

b. The generation unit shall be provided with special sequencing controls to delay lead and lag pump starts unless the generating unit has the capacity to start all pumps simultaneously while the auxiliary equipment is operating.
c. The generation unit shall be capable of shutting down and activating the audible and visual alarms and telemetry if a damaging operating condition develops.
d. The generation unit shall be protected from damage when restoration of power supply occurs.
e. The generator shall be equipped with an automatic transfer switch to start generator and transfer load to emergency in case of utility under voltage, over voltage, power loss, phase reversal, or phase loss.
f. The control panel shall be complete with run-stop-remote switch; remote start-stop terminals; cranking limit; battery charge rate ammeter, oil pressure gauge, temperature gauge; low oil pressure shutdown; high engine temperature shutdown; over speed shutdown; AC voltmeter; voltage adjustment; frequency meter; and running time meter.
g. Circuit breakers shall be provided with a built in control panel.
h. Provide manufacturer's recommended anti-freeze, engine heaters, and suitable trickle battery charger. All accessories shall be engine-mounted and within the weatherproof sound attenuated housing.
i. The manufacturer of the unit shall completely assemble and test the unit before shipment. He shall be one who is regularly engaged in the production of such equipment, and who has spare parts and service facilities. He must also provide 1 complete set of filters.
j. The controls must indicate engine run, common engine fail, transfer switch position, low fuel level, and fuel tank leak for remote telemetry purposes.
k. The automatic transfer switches must have a disconnect on the utility service main side.
l. The generator shall comply with the following minimum requirements:
    i. **Engine:** Four-cycle, 4 cylinder, radiator cooled, at 1800 RPM. Starting shall be from batteries, with capability to start the unit at 32 degrees temperature.
    ii. **Generator:** Rating shall be continuous standby service at 0.8 power factor, at 1800 RPM.
    iii. **Voltage:** Three-phase, 208. KW rating to match facility needs.
    iv. Engine shall be equipped with an isochronous governor as manufactured by Woodall.
    v. Frequency regulation shall be less than 3-cycles from no-load to full load.
m. All accessories needed for the proper installation of the system shall be furnished. Included should be batteries, battery cables, exhaust piping, mufflers, vibration mounting, and three bound sets of detailed operation and maintenance manuals with parts list. Batteries should be lead acid.
n. The generator set shall be enclosed with a factory-installed weather-protective housing (sound abating enclosure to 68db @ 23 ft.) Housing shall provide easy access to the engine-generator and instrument panel. Muffler to be designed so exhaust is not blown or sucked across the set by cooling air.

o. Included with the generator shall be a complete fuel system consisting of a fuel tank, fuel gauge, fuel lines, fuel pumps, valves and any and all other items incidental to a first-quality installation.
p. Provide integral sub-base double-walled diesel tank. The tank is to be UL approved closed-top dike type. The tank shall also be fitted with a leak sensor device. The tank must have a capacity to run the generator for a minimum of 48 hours at 100% load.
q. Tank shall consist of the fuel tank separate and contained within the frame. No generator weight is to be supported by the tank. Provide a drain plug at one end of the rupture basin. Provide vibration isolators between generator set and tank assembly. Provide fuel low-level alarm remote mounted.
r. Provide manufacturer's recommended anti-freeze and engine block heater, per manufacturer's recommendations, with thermostatic controls to maintain engine cool ant at proper temperature to fulfill start-up requirements, adjustable if possible. Provide suitable trickle battery charger. All accessories shall be engine-mounted and within the weatherproof sound attenuated housing.
s. Provide annunciator panels with visual and audible alarms to monitor and warn of emergency operation conditions affecting line and generator power sources.
t. Provide stainless steel super critical grade type exhaust silencer mounted inside of the generator enclosure for corrosion protection.
u. Provide amp meter, voltmeter, and frequency meters with phase switches.
v. Provide fuses or circuit breakers for battery charger and engine.
w. Provide an automatic battery charger, static type, magnetic amplifier control with DC voltmeter, DC ammeter and potentiometer for voltage adjustment. The charger is to be completely automatic and rated for the type of battery use. The charging rate is to be determined by the state of the battery and reducing to milliamp current on fully charged battery. The charger shall be 120 V., single-phase, 60 cycle, AC input with 6-amp maximum output.
x. Operation and Maintenance instructions. The contractor shall provide a minimum of 4 continuous hours of operation and maintenance instructions for the Owner's personnel.
y. The City must be furnished with one complete set of air, oil and fuel filters.

B. **Station Design:**

1) Design of station shall be according to the provisions of the Sewage Collection and Treatment Regulations, Part I, 9 VAC 25-790, *Manual of Practice for Sewerage Systems and Treatment Works,* Article 2, *Sewage Pumping Stations*, 9 VAC 25-790-380 through 430 as published by the Commonwealth of Virginia, Virginia Department of Health (VDH).

2) The pump station shall have a 100% reserve peak pumping capacity (dual pumps) and be capable of pumping at a rate of 2.5 times the average daily flow rate with any one pump out of service. Pump on/off elevations shall be set to achieve 2 to 8 pumping cycles per hour at the average flow rate. When the station is expected to operate at a flow rate less than ½ times the average design flow for an extended period of time, the design shall address

measures taken to prevent septicity due to long holding times of untreated sewage in the wet well.

3) Each pump shall have an individual intake and suction line. Pump suction and discharge piping shall not be less than 4 inches in diameter except where design of special equipment allows.

4) The design velocity in pump piping shall not exceed 6 fps in suction piping and 8 fps in the discharge piping. All pumps shall be provided with an air relief line on the pump discharge piping.

5) **Valve Vaults:** All pumps, connections, shut-off valves, and check valves shall be located in a separate vault above the wet well, allowing accessibility to both the wet wall and pump/vault for inspection, maintenance, etc.

6) The power source, voltage and phasing shall be verified before ordering pumps.

7) Adequate lighting for the entire pump stations shall be provided in accordance with VOSH and other applicable codes and standards.

8) Ventilation shall be provided in accordance with VOSH requirements and shall comply with Article 2, *Sewage Pumping Stations*, 9 VAC 25-790-380 through 430 as published by the Commonwealth of Virginia, Virginia Department of Health (VDH) for enclosed spaces within pump stations during all period when the station is manned. Where the pump is permanently mounted below the ground, mechanical ventilation is required and shall be arranged so that it independently ventilates the dry well.

9) Evaluate the capacity of the receiving sewer main at the point of discharge and downstream to determine that the line can handle the pumped sewer flow.

10) The pump station and force main must be sized to accommodate the total basin area that could gravity flow into it.

11) The City of Fairfax reserves the right to require odor control facilities at pump stations.

12) All control panels must be weatherproofed and have weatherproof identifying labels attached with stainless steel screws.

13) The use of rigid conduit is required.

C. **Wet Wells:**

1) Wet wells shall have the interior walls painted in accordance with the technical specifications, Section 02530 – *Sanitary Sewer*.

2) Buoyancy shall be considered and flotation of the wet wells shall be prevented with appropriate construction where high groundwater conditions are anticipated.

   a. **Computations:** Provide buoyancy calculations to the Utilities Engineer. Assume water to top of structure and structure is empty except that you may include the weight of the liquid below pump off elevation.

3) Surface water shall be directed away from the station pad in all directions.

4) Wet wells and the access road to the site shall be located above the 100-year flood elevation.

5) Provide a screened exterior vent with the end either turned downward or provided with a "mushroom" cap to prevent gas entry to either the panel or pump house enclosure. The vent must be at least 4 inches in diameter.

6) Wet well components shall be located such that normal maintenance and operation of the components can be performed without having to enter the wet well.

7) Seal the electrical conduit running from the wet well to the control panel to prevent gas entry into panel or pump house enclosure.

8) All bolts, mounting brackets, guide rails, pump lift chains, etc. must be stainless steel, sized to support the applicable static and dynamic loads imposed by the equipment. Cable pump lift chains are not permitted.

9) Provisions shall be made to prevent solids deposition. Where used, wet well fillets shall have a minimum slope of 1:1 to the hopper bottom. The horizontal area of the hopper bottom shall be no greater than necessary for proper installation and function of the inlet.

D. **Site:**

1) All mechanical and electrical equipment which could be damaged or inactivated by contact with or submergence in water (motors, control equipment, blowers, switchgear, bearings, etc.) shall be physically located above the 100-year flood or otherwise protected against the 100-year flood. All stations shall be design to remain fully operation during the 25-year flood event.

2) Provide a service head, meter base, service connection, disconnect and area light with photocell.

3) A 10-foot wide all weather access road consisting of 8 inches of VDOT #21 stone on a pre-compacted subgrade graded to drain is to be provided to the station with a turn-a-round area of sufficient size to accommodate turning of City maintenance vehicles. If the lift station easement does not directly abut a publicly dedicated road, a 30 ft access easement shall be provided.

4) When a generator is required, provide an 8-inch thick concrete generator pad.

5) Sites for stations shall be of sufficient size for future expansion or addition, if applicable.

6) An area light on breaker, on a separate circuit from the pumps, shall be provided at the station. The light shall be a minimum of 100-watt sodium high-pressure with a minimum clear mounting height (ground to fixture) of 15 feet.

7) 10 ft x 10 ft x 8-inch concrete pad for water tank with drain and valve.

8) Emergency pump connection with quick connect flange and plug valve.

9) A metered potable water source with non-freeze yard hydrant is required, unless approved otherwise by the Utilities Engineer. The Non-Freeze Yard Hydrant shall be Clayton Mark model 5451 Lever type, Woodford W-34 (3/4”), Woodford Y-1 (1”) frost proof yard hydrant or approved equal.

10) Provide a non-freeze shower w/ eyewash and concrete pad.

E. **Force Mains:** The hydraulic design of force mains shall be based on the following conditions:

1) Force mains shall be designed for a minimum velocity of 2 feet per second and a maximum velocity of 8 feet per second.

2) The minimum size of force mains shall be 4 inches in diameter, except for grinder pumps, which shall be provided with a minimum diameter of 2 inches.

3) Force main materials shall minimum conform to the table in *paragraph 1.3.5 G, Acceptable Pipe Material*.

4) Provide combination air valve air release valves at all high points with differential grade separation of 15 feet or more between high and low points to relief air locking.

5) Force mains shall enter gravity sewer at a manhole or special junction chamber. The force main shall enter the termination structure with its centerline horizontal and at a point no more than 1 foot above the flow line of the receiving gravity sewer. Design of the force main termination structure shall ensure a smooth flow transition to the gravity flow section to prevent turbulence and release of gases. All interior wall of the force main termination structure shall have AgruLiner lining, or approved equal.

6) Force mains shall be sufficiently anchored throughout the line length. The number of bends shall be as few as possible. Thrust blocks, restrained joints, and/or tie rods shall be provided.

7) All force mains shall be tested at a minimum of at least 50% above the design operating pressure, for at least 30 minutes. Leakage shall not exceed the amount given by the formula contained in the most current AWWA standard C 600.

8) A plug valve or valve vault shall be placed outside of the pump station.

9) Sewer force main valve boxes shall have the valve cap marked SEWER.

END OF SECTION 1

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